IMPACT OF COGNITIVE TRAINING ON WORKING MEMORY, VIGILANCE AND SELF-ESTEEM OF COLLEGE STUDENTS

A

Synopsis

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CONCEPTUAL FRAMEWORK

"*Self- esteem is the real magic wand that can form a child's future- Stephanie Martson."* Self – esteem is therefore very important for the students as they step into the world where there is a transition from a dependent to an independent environment. Here, it is important to mention that within this given framework the students are required to show good performance in every walk of life. But, is every student able to perform well? Perhaps the answer is 'No'. Major part of their performance depends on the human brain that has neuroblasts, at the time of birth, which eventually develops into neurons. The human brain has about one hundred billion neurons and the numbers of neuroblasts are approximately double the number of neurons so that the neurons required for survival are available. The neuroblasts which do not develop as neurons wither away. This rate of generation and degeneration of neurons vary across different age groups.

Previously, it was believed that neurons only die and are not generated, eventually, the brains size shrinks and cognitive functioning of the brain like learning and memory weakens. But the brain imaging techniques confirm neurogenesis i.e. generation of neurons to continue throughout life (Jimenez, Garcia, Roncal, Rabano, Cafini, Bazarra, Avila and Martin, 2019). The neurogenesis depends on various factors such as, physical activity, diet, stress and brain training (cognitive). By giving suitable brain training exercises the functional manifestation of improved neurogenesis can be seen in improved memory, learning, vigilance, cognitive functioning and general quality of life and all this will further improve self-esteem as well.

Brain functioning can be improved by appropriate exercise just like other body muscles. By giving specific exercise, the brain and its specific parts will show improvement not only physically but also functionally. The brain has shown to improve attention/concentration, when intervention in the form of video games was given. In addition, subjective measures of enjoyment, motivation, alertness and positive mood remained at high levels after every hour of gameplay in those who played Decoder (Savulich, Thorp, Piercy, Peterson, Pickard and Sahakian 2019). Improvement in physical and functional aspects of the brain includes the alertness of the brain leading to better vigilance.

Vigilance or attention is the ability to concentrate on something and sustain that concentration for a prolonged period and during this period the person tries to detect the change in appearance of the object on which he/she is concentrating. The human behaviour is depended on the things/object/thoughts individuals pay attention to or concentrate upon. Many a times, most individuals are not able to control their focus of attention, resulting in diverted attention. The ability to concentrate decides the content of thoughts and our conscious experience. Vigilance is very important for learning as without focusing attention on the thing to be learned, individuals cannot learn anything. Say for example, while solving Rubik cube, the subject has to be vigilant about the position of the Rubik cube in his/her and movement of desired pieces of the puzzle in the desired direction. Therefore, while solving Rubik cube, the vigilance of the subject will also be in play every single second. In addition to this the working memory of the individual is inevitably focused on in the same context.

Working memory is a very important part of memory and everyday life. The things our brain is able to remember for 30 seconds or less comes under short term memory. However, all the material in short term memory is not used by the brain. The information existing in short term memory, which is used for planning the next step, take decision, solving a problem or giving reply during a conversation, is termed as working memory. For an individual's various day to day activities, not only long term memory is used (knowledge, experience and wisdom) but also short term memory and working memory which connects various logics and reasoning, which is drawn upon while taking decisions. Even while having a normal conversation, individuals are able to comprehend and reply by relying on their working memory.

The working memory and vigilance are two such aspects that every person, irrespective of age, requires for proper cognitive functioning in all spheres of life including routine activities. Keeping in view the importance of these two variables in everyone's life, throughout life, these variables have been selected. It is also important to mention here that if the day to day activities and choices made, as a result of being vigilant and having good application of working memory, the self-esteem of the individuals is also boosted up as they would feel good about themselves, their performance, their life etc.

Self-esteem is the overall sense of self-worth of what individuals think they are capable of doing or accomplishing. The self-esteem is developed by an individual by estimating his/her accomplishments over a period of time. The more a person is able to accomplish, the better his/her self-esteem becomes. It leads to a feeling of competence, to be able to face basic day to day challenges of life and deserving happiness. If an individual is able to do things, which he/she earlier thought to be impossible or extremely difficult, the self-esteem is likely to improve e.g. learning a complex task and accomplishing it well. This is also supported by a research showing that by teaching problem solving, the self-esteem of subjects improves (Ghahfarokhi, Moradi, Albarozkouh, Radmehr, and Zainali, 2015).

A complex task like learning algorithms of a Rubik cube is a problem in the form of a puzzle and is difficult to solve unless someone teaches. Considering this, when an individual is able to solve a problem, which is impossible for them to solve on their own, it is expected their self-esteem will improve. Self-esteem is a key factor in estimating what an individual thinks about his/her ability to solve a problem. Therefore if there is improvement in the self-esteem of individuals, chances of improved performance in their respective area(s) of interest and related activity are also higher.

Here, it is important to mention that 3X3 Rubik cube was designed by the Hungarian structural engineer Erno Rubik in 1974. Rubik cube puzzle is a very famous brain game, which is difficult to solve by trial and error method because of the sheer enormity of number of possible positions of various pieces of Rubik cube. There are six faces in a Rubik cube and each face is having nine pieces. The number of possible combinations of all the pieces of Rubik cube runs into billions. The Rubik's cube is a puzzle and to solve this cube from scrambled position requires a strategy, memorizing the several sets of specific algorithms (which are meaningless alphabets), executing them in exact sequential order (without even a single error), hand eye coordination and perfect situational awareness (of position of Rubik cube held in hand). Without all these, the Rubik cube cannot be solved. Due to above mentioned reasons, ability to solve Rubik cube is neither a common skill, nor it can be acquired easily specially by the students who have been low performers as well.

Different variations of Rubik's Cubes ranging up to thirty-three layers are available. Out of these the 2×2×2 (Pocket/Mini Cube), the standard 3×3×3 cube, the 4×4×4 (Rubik's Revenge/Master Cube) and the 5×5×5 (Professor's Cube) are well-known. Till 1981, the official Rubik's brand licensed twisty puzzle cubes only up to the 5×5×5. The 17×17×17 "Over The Top" cube (2011) was in limelight until December 2017. This largest and most expensive cube, costing more than two thousand dollars commercially sold was mass-produced and 17×17×17 was later introduced by the Chinese manufacturer YuXin. Later, a working design for a 22×22×22 cube existed and was demonstrated in January 2016 alongside a 33×33×33 in December 2017. Non-licensed physical cubes as large as 17×17×17 based on the V-Cube patents are commercially available; these represent about the limit of practicality for the purpose of "speed-solving" competitively. Although there are a significant number of possible versions for the Rubik's Cube, a number of solutions have been developed, which allow solving the cube well in under 100 moves.

Many general solutions for the Rubik's Cube have been ascertained independently. Singmaster (1981) first published his solution in the book notes on Rubik's "Magic Cube". This solution implicates solving the Cube layer by layer, in which top layer is solved first, followed by the middle, and then the final and bottom layer. After adequate practice, Cube solving can be done within one minute. Another solution includes "corners first" method and several other methods. Singmaster and Frey (1982) hypothesized that approximately twenty moves are needed to solve the Rubik's Cube, with an ideal algorithm. Kunkle (2007) used computer search methods to demonstrate that any 3×3×3 Rubik's Cube configuration can be solved in 26 moves or fewer. Rokicki (2008) lowered that number to 22 moves, and in 2010, Rokicki and his team working with Google proved the "God's number" to be 20. This is optimal with some starting positions, which require a minimum of 20 moves to solve. Generally, an n×n×n Rubik's Cube can be solved optimally in $\Theta \{n2 / \log (n)\}$ moves. When individuals solve Rubik cube their long term memory, short term memory, vigilance and hand eye coordination are in play. Therefore, while learning how to solve Rubik cube, parts of brain executing these functions will be activated and are likely to improve physically as well as functionally.

Though Rubik Cube is a tough problem to solve but it is a fun activity as well. According to Singh (2014) there is a positive and significant correlation between metacognition and problem solving ability, and also between metacognition and self-esteem. Self-esteem is very important at every stage of life as it is essential for determining good adjustment. Throughout life individuals need high self-esteem even to attempt difficult things leaving aside assuring success. An individual will be paying the cost of low self-esteem at every stage of life for example, during adolescence, low self-esteem has been found to be associated with low academic achievement, teenage pregnancy, eating disorders, drug abuse, juvenile delinquency and sexually transmitted diseases (Galliher, Rostosky and Hughes, 2004). Also, low self-esteem in early adolescence has been found to be a predictor of depression in late adolescence and early adulthood (Masselink, Roekel and Oldhinkel, 2018). During adulthood, low self-esteem has been related to not exceling in one's profession, not being able to sustain long periods of employment and not being able to initiate and sustain intimate relationships. Also, low self-esteem has been found to be one of the causes of depression, anxiety, suicidal tendencies and social anxiety. Due to the changing demands of life and society, the self-esteem especially takes a dip during transition periods of life from adolescence to adulthood. During this period they tend to lose interest as things are just not going right in the life. Such students need attention to boost up their alertness and concentration along with self-esteem.

Eventually, self-esteem seems to show improvement with accomplishment of difficult tasks, especially if the individual considers it impossible to accomplish. The same concept applies to the college going students also. Anyone who is able to acquire any rare skill, which initially appeared to be impossible, is most likely to improve his/her self-esteem. Solving Rubik cube is a rare skill because unless someone knows all the algorithms in correct and sequential manner, no one can solve it. Therefore, by teaching how to solve Rubik cube puzzle, which appears to be impossible to solve and imparting cognitive training through solving Rubik cube puzzle it is expected that students will show improvement in their working memory, vigilance and self-esteem. Considering all these aspects the research questions to be explored are framed '*Will giving cognitive training in form of solving Rubik Cube puzzle bring any improvement in the*

working memory, vigilance and self-esteem of college students who score low on these aspects?', '*Will the expected improvement in working memory, vigilance and self- esteem bring about any observable qualitative change in the student's class performance or life?', Will Rubik Cube be a successful strategy to help these students in need?'* The conceptual framework of the study is given below in figure 1.

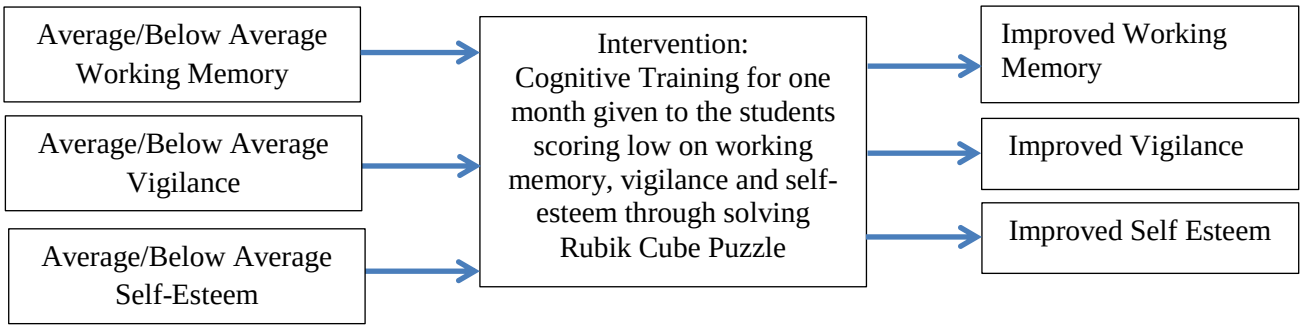

Average/Below Average Working Memory
Average/Below Average Vigilance
Average/Below Average Self-Esteem
Intervention: Cognitive Training for one month given to the students scoring low on working memory, vigilance and self-esteem through solving Rubik Cube Puzzle
Improved Working Memory
Improved Vigilance
Improved Self Esteem

Figure 1: Conceptual Framework of the study

The researches were reviewed to find out the gap in the literature on the concepts. The researches reviewed are summarized and presented in the table below.

SUMMARY OF THE REVIEW OF RELATED RESEARCHES

Author/Year	Variables	Outcomes
Jimura , Chushak , Westbrook , Braver (2017)	Inter temporal decision-making was directly compared with Working Memory load-related activation using functional magnetic resonance imaging.	Results suggest a more precise account of the relationship between Working Memory and inter temporal decision-making that is specifically tied to choice difficulty, and involves the coordinated activation of a lateral PFC circuit supporting successful self-control.
Vartanian, Jobidon , Bouak , Nakashima , Smith, Lam , et al. (2013)	Hypothesis tested was that Working Memory training would improve performance and moderate neural function in the Alternate Uses Task (AUT)-a classic test of divergent thinking.	Participants in the experimental group exhibited significant improvement in performance in the WM task as a function of training, as well as a significant gain in fluid intelligence. Furthermore, gain in fluid intelligence mediated the effect of training on brain activation in ventro-lateral prefrontal cortex. These results indicate that a short regimen of Working Memory training is associated with lower prefrontal activation-a marker of neural efficiency-in divergent thinking.
Mongillo , Barak and Tsodyks (2008).	Working Memory and synaptic facilitation.	Because of the long time constants of calcium kinetics, the refresh rate can be low, resulting in a mechanism that is metabolically efficient and robust. The duration and stability of working memory can be regulated by modulating the spontaneous activity in the network.

Monleón, Ballester, Sanchis, Llorens, Martín and Pablos (2015)	Effects of Eight-Month Physical Activity Intervention on Vigilance Performance in Adult Obese Population	The results revealed that participants improved their cardiorespiratory fitness, BMI, and vigilance performance after the intervention. All in all, findings contribute new empirical evidence to the field that investigates the benefits of physical activity intervention on cognitive processes in obese population.
Warm, Mathews and Parasuraman (2008)	Vigilance is reviewed in four areas: studies of task type, perceived mental workload during vigilance, neural measures of resource demand in vigilance, and studies of task-induced stress	Workload of vigilance is high and sensitive to factors that increase processing demands. Neuroimaging studies using trans cranial Doppler sonography provide strong, independent evidence for resource changes linked to performance decrement in vigilance tasks. Finally, physiological and subjective reports confirm that vigilance tasks reduce task engagement and increase distress and that these changes rise with increased task difficulty. Converging evidence using behavioural, neural, and subjective measures shows that vigilance requires hard mental work and is stressful.
Oken, Salinskey and Elsas (2006)	Vigilance, alertness, or sustained attention: physiological basis and measurement	There are a number of neural and functional systems relatively directly affecting phasic and tonic alertness. In addition, there are a number of systems that directly modulate these alertness systems, such as the neural systems related to motivation and stress. The multiple constructs and neural systems underlying the relatively non-specific phasic and tonic alertness activation states imply that they are not unidimensional. Thus, one should rarely, if ever, simplify and speak about vigilance or alertness on a unidimensional continuum.
Masselink, Roekel and Oldhinkel (2018)	Self-esteem, Depression, Motivation, Social problems, Avoidance, Social support	Self-esteem in early adolescence predicted depressive symptoms in late adolescence as well as early adulthood. The effect sizes were relatively small, indicating that having low self-esteem is a vulnerability factor, but does not necessarily predispose adolescents to developing depressive symptoms on their way to adulthood.
Sharma and Agarwala (2015)	Self Esteem and Collective Self Esteem	There was significant difference between pre-intervention collective self-esteem scores and post-intervention collective self-esteem scores. Thus, the results proved the effectiveness of interventional program in enhancing self-esteem and collective self-esteem.

Singh (2014)	Metacognition, problem solving and self-esteem	(i) There is a positive and significant correlation between metacognition and problem solving ability; (ii) a positive and significant correlation found between metacognition and self-esteem; (iii) the urban students have more metacognition in comparison to rural senior secondary students; (iv) male students have more metacognition in comparison to female senior secondary students; (v) students having high problem solving ability have more metacognition in comparison to the students having low problem solving ability; (vi) students having high self-esteem have more metacognition in comparison to the students having low self-esteem; (vii) male students having high problem solving ability have more metacognition in comparison to the male students having low problem solving ability; (viii) female students having high problem solving ability have more metacognition in comparison to the female students having low problem solving ability; (ix) male students having high self-esteem have more metacognition in comparison to the male students having low self-esteem; (x) female students having high self-esteem have more metacognition in comparison to the female students having low self-esteem; (xi) rural senior secondary students having high problem solving ability have more metacognition in comparison to the rural senior secondary students having low problem solving ability; (xii) urban senior secondary students having high problem solving ability have more metacognition in comparison to the urban senior secondary students having low problem solving ability; (xiii) rural students having high self-esteem have more metacognition in comparison to the rural students having low self-esteem; and (xiv) urban students having high self-esteem have more metacognition in comparison to the urban students having low self-esteem.
Nouchi and Kawashima (2014)	A systematic review of intervention studies of improvements of cognitive functions published or in press before December 2013	Nine completed and published studies were identified, which were divided into four categories: cognitive training using video game, cognitive training using PC, cognitive training using paper and

		pencil, and exercise training. Review results showed that various intervention programs can improve cognitive functions such as executive functions, working memory, episodic memory, processing speed, and general cognitive ability/IQ. Conclusions. The systematic review demonstrated that some intervention programs can be effective for improving various aspects of cognitive functioning at any age. Some limitations to this review include its small sample size and heterogeneity of programs and cognitive function measures, in addition to unresolved issues such as transfer of everyday skills and effectiveness for non-healthy people.
Joshi and Srivastava (2009)	Self-Esteem, Academic Achievement and Rural/Urban background	The findings indicated that there were no significant differences with regard to self-esteem of rural and urban adolescents. There were significant differences with regard to academic achievement of rural and urban adolescents. Urban adolescents scored higher in academic achievement as compared to rural adolescents. Boys would score significant higher on self-esteem as compared to girls. Significant gender differences were found in academic achievement. Compared to boys, girls were significantly higher on academic achievement.
Masselink, Roekel and Oldhinkel (2018)	Self-esteem, Depression, Motivation, Social problems, Avoidance, Social support	Self-esteem in early adolescence predicted depressive symptoms in late adolescence as well as early adulthood. The effect sizes were relatively small, indicating that having low self-esteem is a vulnerability factor, but does not necessarily predispose adolescents to developing depressive symptoms on their way to adulthood.
Swanson (1983)	Attentional deficit in learning disabled children.	Learning-disabled children made fewer correct detections and more false responses and were less sensitive to critical stimuli than were nondisabled children at all ages. Learning disabled children apply different response criteria across age when compared to nondisabled children. The popular notion that learning-disabled and younger subjects start a vigilance task with the same capacity as nondisabled older children but show a decline in attention as time on task increases was

		not supported.
Savulich, Thorp, Piercy, Peterson, Pickard and Sahakian (2019)	Attention and Cognitive Training with "Decoder" game	The main finding of this study was that attention/concentration was significantly improved by playing the Decoder game on an iPad, which was developed for cognitive training. In addition, subjective measures of enjoyment, motivation, alertness and positive mood remained at high levels in those who played Decoder after every hour of gameplay.
Motes, Yezhuvath, Aslan, Spence, Rypma, and Chapman. (2018).	Cognitive training and processing speed related neural activity	Cognitive training led to a change in processing speed–related neural activity where faster processing speed was associated with reduced Pre Frontal Cortex activation, fitting previously identified neural efficiency profiles.
Smith (2014)	Cognitive training, memory, reasoning and speed of processing	Cognitive training aimed at boosting older adults skills at memory, reasoning and processing speed slowed their cognitive decline and helped maintain functioning in daily living tasks over a decade.
Vleet, DeGutis and Robertson (2007)	Cognitive rehabilitation of patients with hemi spatial neglect: Effects of vigilance training on components of attentional processing	Post-training assessment revealed significant improvement in several attentional domains (e.g., spatial search, object-based attention, sustained attention, selective attention). Notably, vigilance training promoted balanced search efficiency between contra and ispilesional space. While effects on spatial processing faded over the course of follow-up testing (1–2 weeks), benefits in non-spatial domains of attention (e.g., selective attention, vigilance) were longer-lasting. These results suggest that training non-spatial mechanisms of attention may provide beneficial short-term improvements across a number of attentional processing domains while longer-lasting benefits may be specific to the training domain.
Ghahfarokhi, Moradi, Albarozkouh, Radmehr and Zainali (2015)	Impact of Training Problem Solving Skills, Self-Esteem and Behavioral Adjustment.	Findings obtained from analyzing the single-variable and multivariate covariance showed that training problem-solving skills have a significant effect on self-esteem and behavioral adjustment in girls with irresponsible parents or no parents

GAP ANALYSIS AND RESEARCH DIRECTIONS

The available articles and researches are mainly indicating about neurogenesis, functioning of brain, its various cognitive functions, for example short term and working memory, benefits of brain training and self-esteem but none of the researches links all these factors together. Studies in the review mention about attention and cognitive training with "Decoder" game; Cognitive training and processing speed related neural activity; Cognitive training, memory, reasoning and speed of processing; Cognitive rehabilitation of patients with hemi spatial neglect and effects of vigilance training on components of attention processing; physiological basis and measurement of vigilance, alertness, or sustained attention; effects of eight-month physical activity intervention on vigilance performance in adult obese population. The studies on self-esteem mention about academic achievement in connection to rural/urban background; self-esteem as related to depression, motivation, social problems, avoidance and social support, i.e. mainly in social context. The studies mention about the memory but the researcher here is interested in improving working memory.

Most of the interventions used in researches require trained psychologists, technical expertise and involvement of many people. In this study, one person will be conveniently giving intervention to various subjects simultaneously. The result of this experimental study will have wider implications across all age groups and across all cultures. Based on the results of this experimental study, the intervention can be given by anyone to everyone across every culture since the intervention is culture free.

Also, the tool used for intervention is economical and easily available across the globe and anyone can be trained to give this intervention even if the person is not having any knowledge of psychology. The intervention is so fun filled that the subject especially younger generation, if willing, will enjoy the intervention, which will further boost the brain functioning. Besides, the subject is required to have very minimal educational and physical abilities, therefore almost all those who need it, can be given this intervention.

This experimental study can be further extended to include functional magnetic resonance imaging (FMRI) technique to study changes in brain activation level as a result of this

intervention, which is likely to improve neurogenesis, slow down neuro degeneration and create new synaptic connections, as a result of which the overall brain functioning and confidence of the subject is most likely to improve. Therefore, this experimental study is going to have much more wider implications than being intended in this study.

Also, if early detection of any cognitively degenerative disease e.g. Alzheimer's Disease is done, then this intervention can be useful in delaying the effect of cognitive degeneration due to improved neurogenesis.

RATIONALE OF THE STUDY

From childhood till death individuals perform various tasks; some of the tasks are physical, and others mental, while some require a combination of physical and mental abilities. In childhood most of the tasks are new and they improve our physical and mental abilities. As a child grows older, the physical and/or mental efforts required to be applied to solve a new problem becomes lesser because the novelty of the problem is lost, the more a problem becomes familiar the more it becomes easy to solve it, due to the automation of thoughts and physical activities.

With increasing age, individuals encounter fewer unfamiliar problems; therefore our brain becomes more automated and requires lesser efforts to solve the problems. Like any other body part, the brain also needs exercise as along with the body brain ages with passage of time. When suitable exercise is given, the ability of brain can be improved, while degeneration of the brain cells can be slowed.

Solving Rubik cube is a rare skill. Once an individual is able to solve apparently impossible problem and acquires a rare skill, it certainly improves the self-esteem of the subject (Ghahfarokhi, Moradi, Albarozkouh, Radmehr, Zainali, 2015). Anyone who does not know how to solve the Rubik cube puzzle will get brain exercise while learning to solve it. The researcher wants to study the impact of cognitive training (with solving Rubik cube puzzle) on working memory, vigilance and self-esteem on college going students in the age group of 18 – 25 years. The age group of subjects has been selected keeping in view the demographic representation of this age group in India. As of now, about fifty percent of the population of India is below 25 years of age. Also, individuals of this age group are about to begin their professional life where

working memory, vigilance and self-esteem are of great importance for success. This section of the population is expected to show performance to a greater extent by their family and society. Whether they perform well or do not perform well the pressure of performing better remains, more for the group that does not perform well and does not fit into the criteria of good performance stated by the society. Some of these young fellows need help as many of them tend to lose interest in performing well and may even think of ending their life. So, the researcher is likely to provide these students with a tool/ technique, which is challenging enough and will aptly boost their brain activation level. The happiness acquired after accomplishment of a complex task will make them feel positive enough to show remarkable improvement in their behavior and responses as well. Therefore, for this current project the target population is only the college students.

RESEARCH METHOD

The study will be conducted in two parts; in the first part the baseline measure of the students on working memory, vigilance and self-esteem will be taken. Based on the responses and scores on each of the above mentioned variables, students will be categorized as low, average and high. Thereafter, the selected group of willing students from low and average category will be given cognitive training intervention in the form of solving Rubik cube for one hour per day for approximately four weeks. After the intervention is complete, the subjects will again be tested on working memory, vigilance and self-esteem to obtain a post measure, to find out the effect of the intervention. The second part of the study will comprise of the in-depth case studies of 3-6 students, showing remarkable change in their scores, responses as well as their behaviour.

PART 'A'

OBJECTIVES

- To explore the possibility of Rubik Cube as a device of cognitive training for students low on working memory, vigilance and self-esteem
- To study the impact of Cognitive Training intervention (with Rubik Cube) on working memory, vigilance and self-esteem of college students.

HYPOTHESIS

- Cognitive training intervention (with Rubik cube) would significantly impact working memory, vigilance, and self-esteem of college students.

VARIABLES

INDEPENDENT VARIALBE

- Cognitive Training intervention (solving 3X3 Rubik Cube puzzle)

DEPENDENT VARIABLES

(1) Working Memory (2) Vigilance (3) Self-Esteem

OPERATIONAL DEFINITION OF THE TERMS USED

Working Memory: The part of short term memory (STM) and material from LTM, concerned with immediate conscious perceptual and linguistic processing. It is the thinking and reasoning skill that focuses on memory in action, the ability to remember and use relevant information while in the middle of an activity.

Vigilance: When something is not happening and a person is paying sustained attention in the hope that something happens and he/she is able to detect it.

Self-Esteem: refers to individual's personal judgment of his or her own worth; one's attitude towards oneself. It is the self-evaluation of an individual regarding what he/she can or cannot do.

SAMPLE DESCRIPTION

Multi stage sampling will be done.

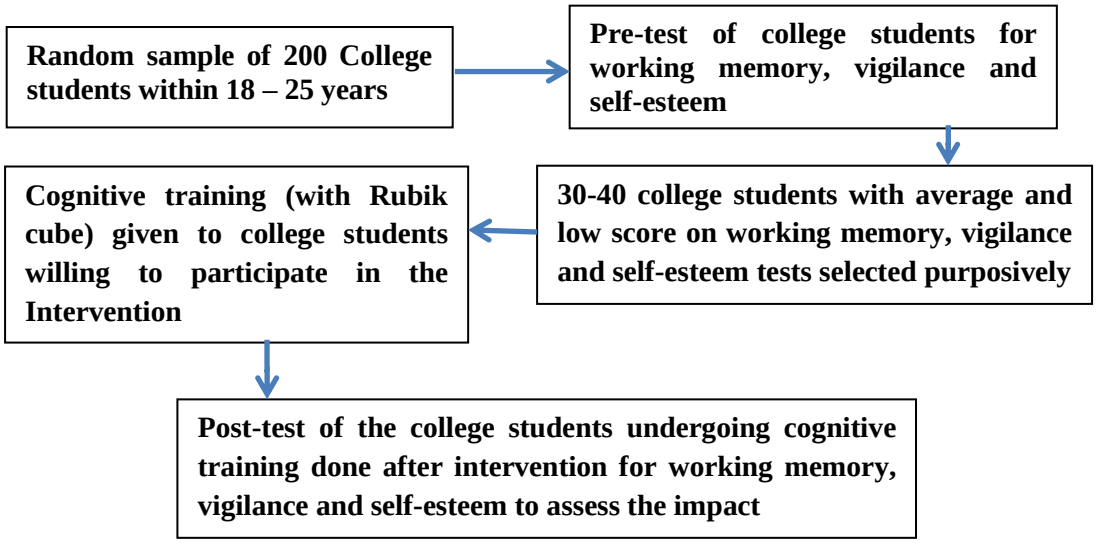
A stratified random sampling based on age, education and gender etc., will be used. Sample will comprise of 200 college students who have passed 12^{th} standard. Both male and female students from universities in and around Agra, Delhi and NCR, in the age bracket of 18 – 25 years will be included in the sample. They will be tested on working memory, vigilance and self-esteem. From this sample, students will be further categorized as having low, average and high vigilance, working memory and self-esteem based on the interpretation of the scores.

From the total sample 30-40 willing students having low and average vigilance, working memory and self-esteem will be purposively selected for giving intervention and given

cognitive training with solving 3X3 Rubik Cube puzzle, for one hour / day, for a total duration of four-six weeks. Then a post measure of the variables under consideration will be taken to assess the impact on working memory, vigilance and self-esteem of the students.

Students having average mental ability to understand instructions and follow them will be included. Students having any kind of disability, especially with eyes i.e. not able to recognise different colours of Rubik cube separately, or have disability with hands that prevents the subject from rotating various pieces of the cube as per the algorithm or have hearing impairment, will be excluded from the study. Students undergoing psychiatric or psychological treatment or who have solved Rubik cube earlier will also be excluded from the sample. Figure 2 below displays the framework and stages of the sample selection.

Figure 2: Framework of sample selection and Intervention plan


Random sample of 200 College students within 18 – 25 years
Pre-test of college students for working memory, vigilance and self-esteem
30-40 college students with average and low score on working memory, vigilance and self-esteem tests selected purposively
Cognitive training (with Rubik cube) given to college students willing to participate in the Intervention
Post-test of the college students undergoing cognitive training done after intervention for working memory, vigilance and self-esteem to assess the impact

TOOLS

1. **Wechsler Adult Intelligence Scale** (WAIS – III) – This test was developed by Wechsler in 1997. This test consists of 14 sub-tests (seven verbal and seven non-verbals). Out of these 14 sub-tests, only three tests i.e., digit span, arithmetic and letter-number sequencing, measuring working memory will be used in the present research. This test is very well known and is highly reliable and valid.

2. **Bourdon – Wiersma Vigilance Test** – This dot cancellation test is used to measure perceptual speed and perceptual accuracy indicating vigilance of students. The test consists of 50 rows of groups of 3, 4 or 5 dots with 8 groups of 4 dots in each row. The task is to strike out the groups of 4 dots in each row as accurately and quickly as possible within 4 minutes. The test is sufficiently reliable and valid and used for various researches earlier.
3. **Self-Esteem Scale –** This test was developed by Santosh Dhar and Upinder Dhar to measure self-esteem. This test consists of 23 items divided into six areas i.e., positivity, openness, competence, humility, self-worth and learning orientation. The test is having a reliability coefficient of 0.87 and high validity of 0.93.

RESEARCH DESIGN: Pre and post-test design will be used for studying the impact of cognitive training (with Rubik cube) on working memory, vigilance and self-esteem of the students.

PROCEDURE AND INTERVENTION PLAN

Validation of Cognitive training device

As per the available literature, so far, Rubik cube has not been used as an intervention device in any psychological experiment. Therefore, a pilot study with a small group of subjects was done to make an estimation of the validity of the Rubik cube as an effective cognitive training device used in the intervention for improving working memory, vigilance and self-esteem of the students. The details of the results of pre and post measure as well as observations show on an average 21% improvement in working memory; around 25% improvement in vigilance and slight improvement in confidence and self-esteem. An increased participation in class room activities; increase in happiness and expressiveness and eagerness to participate in similar activities (like learning 4X4 and 5X5 puzzles) was also observed. Based on the experiences during the pilot study an intervention schedule and procedure was determined.

Table1. Tentative Schedule of Intervention to be followed for the study

Day 1 & 2	**Day 3 & 4**	**Day 5 & 6**	**Day 7 & 8**	**Day 9 & 10**	**Day 11 & 12**	**Day 13 & 14**	**Day 15- 19**	**Day 20**
Students taught algorithm of 1st step of Rubik Cube puzzle and given practice	Students taught algorithm of 2nd step of solving Rubik Cube and given practice	Algorithm of 3rd step of solving Rubik Cube taught and given practice	Algorithm of 4th step of solving Rubik Cube taught and given practice	Algorithm of 5th step of solving Rubik Cube taught & given practice	Algorithm of 6th step of solving Rubik Cube taught and given practice	Algorithm of 7th step of solving Rubik Cube taught and given practice	Students told to solve Rubik Cube, as fast as possible, in one go	Students tested on their ability to solve Rubik cube– three trial given

Procedure of the study

Thirty to forty students purposively selected in the age group of 18 – 25years, having low or average working memory, vigilance and self-esteem will be given cognitive training with solving 3X3 Rubik Cube for an hour per day for a period of approximately four weeks. The willing subjects fitting in the selection criteria will be taught to solve the 3X3 Rubik Cube using beginner's (layer by layer) method in seven sequential algorithms, steps by step. When the students are able to solve the 3x3 Rubik cube in less than three minutes the researcher will bring about some variations in the patterns of the cube like cross pattern with the same colour.

STATISTICAL TECHNIQUE

Structural Equation Modelling (SEM) for the three variables in the study will be used. Wilcoxon T Test will be used to compare the changes after the intervention in working memory, vigilance and self-esteem separately for each age group.

Part 'B'

QUALITATIVE ANALYSIS

The second part of the study will focus on in-depth case studies of three to four students showing remarkable improvement in their working memory, vigilance or self-esteem scores and also those not showing any considerable improvement. This will be done to make an

assessment, if there is an improvement in the student's scores on variables under consideration, is it specifically because of the intervention given.

OBJECTIVES

- To explore the background (family, peers etc.), aspirations, interests and life style by means of in-depth case study, of the students showing and not showing considerable improvement in their working memory, vigilance and self-esteem scores
- To compare the EEG data of the students under consideration while participating in the cognitive training (with Rubik cube)

ASSUMPTIONS

- Students showing a remarkable improvement/or not showing any considerable change in their working memory, vigilance and self-esteem scores will have specific differences in their background, aspirations, interests and lifestyle
- The brain activation level measured through EEG will show multiple variations with different students ranging from very high to very low activation level during the cognitive training (with Rubik cube)

RESEARCH DESIGN: In-depth Case studies will be conducted to generate data for the qualitative analysis

TOOLS: (1) Unstructured interview schedule (for background, family, peers etc., aspirations, interests and life style of students) (2) Physio-pac for EEG data will be used to generate data for the second part of the study.

PROCEDURE: These students purposively selected for the Part 'B' of the study will be taught and made to practice 4X4 and 5X5 Rubik's Cube as per their capacity, also to increase the difficulty level of the task, their EEG data will be generated. A baseline EEG data will be taken before performing the activity and then while performing the activity for 10 days. A comparison and interpretation of this data will be done to explore if any difference in the brain activation level exists.

Further, after the data for EEG is generated, an unstructured interview to explore much more in depth about the students showing high and no change in their score of working memory,

vigilance and self-esteem will be conducted for qualitative analysis. Interpretation and analysis of the responses from interview will be done using content analysis.

IMPLICATION OF THE STUDY

As people age, we get lesser brain exercise due to automation of our thoughts and activities. Deterioration of brain and its functioning is taken as granted by people as a function of time and age. Impact of working memory and vigilance is immense on learning and day to day life, throughout life. If we can experimentally prove the utility of cognitive training in improving ability of brain in terms of working memory and vigilance, it will be helpful for people across different age groups. If people can be helped to improve their working memory, vigilance and self-esteem, then certainly it will not only help the individual but also the society at large. By means of a fun activity the students or any individual will activate the areas to the maximum. This pleasure of doing good on a complex task may also impact the life's day to day performance.

Currently about sixty five percent of the Indian population is below 35 years of age and about fifty percent of the population is below 25 years of the age. Through this research study, the researcher aims to benefit the younger generation to improve their brain activation, in terms of working memory and vigilance and sustain or improve the functioning of the brain, with implications even for old age people with working memory and vigilance along with self-esteem, as extremely important during old age. As a whole, it will benefit all the age groups across different cultures and societies.

In case, the brain training is found to have impact on a particular age group(s), then study on that particular age group(s) to assess the impact of brain training FMRI (Functional Magnetic Resonance Imaging) or other suitable brain imaging techniques can also be used.

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